



University of
Massachusetts
Lowell

Memorial Service and Technical Symposium

UNIVERSITY OF MASSACHUSETTS LOWELL



Honoring

Sukant K. Tripathy

February 15 and 16, 2001



UNIVERSITY OF MASSACHUSETTS LOWELL
MEMORIAL SERVICE
AND
TECHNICAL SYMPOSIUM
HONORING
SUKANT K. TRIPATHY

February 15 and 16, 2001

Memorial Service
February 15, 2001—Coburn Hall

ORDER OF SERVICE

LUX AETERNA

By John Rutter, from his Requiem Mass.
Laura Katz, soprano soloist
University of Massachusetts Lowell Chamber Singers
Dr. Christopher McGahan, music director

SPEAKERS

Chancellor William T. Hogan
University of Massachusetts Lowell
Dr. Kenneth Geiser, master of ceremonies
University of Massachusetts Lowell
Dr. Jayant Kumar
University of Massachusetts Lowell
Dr. Daniel Sandman
University of Massachusetts Lowell

POEM

Dr. Celeste Kostopulos Cooperman
Suffolk University

SINDHU-BHAIRAVI RAGA

Dr. Suresh Mathur, flute
Accompanied by written messages of condolence

SPEAKERS

Dr. Krishna Vedula
University of Massachusetts Lowell
Dr. Alexandre Blumstein
University of Massachusetts Lowell
Dr. Michael Rubner
Massachusetts Institute of Technology

Dr. Hachiro Nakanishi
Tohoku University

Dr. Kenneth Wynne
Virginia Commonwealth University

POEM

Dr. Elizabeth Cavicchi
Harvard University

HYMN TO SARASWATHI, GODDESS OF KNOWLEDGE

Dr. Chandrika Sharma, accompanied by
UMass Lowell students

COMPOSITION BY 12TH CENTURY POET JAYADEV,
FROM THE STATE OF ORISSA

Dr. Chandrika Sharma, singer
University of Massachusetts Lowell

SPEAKERS

Dr. Alan MacDiarmid, Nobel laureate
University of Pennsylvania

Dr. Anthony Guiseppi-Eli
Virginia Commonwealth University

Dr. Stanley Israel
Southwest Texas State University

Dr. Long Chiang
National Taiwan University

Sheila and Aneil Tripathy

VIDEO

Photographs provided by family, friends, and colleagues
of Sukant K. Tripathy

Light refreshments-cookies and punch-will follow the service.

Technical Symposium
February 16, 2001—Wannalancit Mills

ORDER OF PROGRAM

08:30-09:00 a.m. Registration and Coffee

Morning Session: Chair: Dr. Arthur Watterson, University of Massachusetts
Lowell

09:00-09:05 Provost Robert Wagner, University of Massachusetts Lowell
Opening Remarks:

09:05-09:45 ✓ Dr. Alan Heeger, Nobel laureate, University of California,
Santa Barbara
*Semiconducting and Metallic Polymers: Fourth Generation of
Polymeric Materials*

09:45-10:30 ✓ Dr. Alan MacDiarmid, Nobel laureate,
University of Pennsylvania
"Synthetic Metals" A Novel Role for Organic Polymers

10:30-10:45 Coffee Break

10:45-11:10 Dr. Yang Yang, University of California, Los Angeles
The Search for High Performance Polymer Electronic Devices

11:10-11:35 Dr. Jerome Lando, Case Western Reserve University
*Surface Molecular Structure Determination of the Lithium
Salt of 10, 12-Nonacosadiynoic Acid Monomer and Polymer
Langmuir-Blodgett Films by Scanning Force Microscopy
Compared to Electron Diffraction Results.*

11:35-12:00 Dr. Hachiro Nakanishi, Tohoku University
*Hetero-Multilayered Thin Films Made up of Polydiacetylene
Microcrystals and Metal Fine Particles.*

12:00-1:30 Lunch and Poster Presentations

Afternoon Session: Chair: Dr. Daniel Sandman, University of Massachusetts Lowell

- 01:30-01:55 Dr. Michael Rubner, Massachusetts Institute of Technology
*Molecular-Level Processing of Polymers: a Means to Control
the Function and Performance of Thin Film Devices.*
- 01:55-02:20 Dr. Seizo Miyata, Tokyo University of Agriculture
and Technology
Bright Scarlet Electroluminescence of Organic Dye
- 02:20-02:45 Dr. Kenneth Wynne, Virginia Commonwealth University
Surface Tension-Confined Microfluidics
- 02:45-3:00 Coffee and Dessert
- 03:00-03:25 Dr. Gary Wnek, Virginia Commonwealth University
Electrospinning of Biomaterials
- 03:25-03:50 Dr. Hiroyuki Sasabe, Chitose Institute of Science
and Technology
Carbazole Polymers for Photonics Applications
- 03:50-04:05 Dr. Robert Metzger, University of Alabama
Unimolecular Rectifiers: from Waltham to Exeter to Tuscaloosa
- 04:05-04:15 Dr. A.L. Cholli, UMass Lowell, Concluding Remarks

SPEAKER ABSTRACTS AND BIOGRAPHIES

Semiconducting and Metallic Polymers: The Fourth Generation of Polymeric Materials

Dr. Alan Heeger, Nobel laureate, University of California, Santa Barbara

Abstract

A brief review of the science of conducting polymers will be presented with emphasis on the special features of these materials that will lead to new opportunities for technology.

Biography

Alan J. Heeger was born in 1936 in Sioux City, Iowa. He received his bachelor's degree from the University of Nebraska with High Distinction and his Ph.D. in physics from the University of California, Berkeley. An interdisciplinary scientist, Heeger created a new field of research and technology-conjugated polymers. He has sustained a leadership role in this developing field, always on the frontier and always with the challenge of exciting discoveries. Heeger is Professor of Physics and Professor of Materials (joint appointment) at UCSB, where he also serves as Director of the Institute for Polymers and Organic Solids. He is a founder of UNIAx Corporation where he continues as Chairman and Chief Scientist. Heeger was a Sloan Foundation Fellow (1963-1965), a John Simon Guggenheim Fellow (1968-1969), and was elected to Fellowship in the American Physical Society in 1968. He was awarded the Oliver E. Buckley Prize for Condensed Matter Physics in 1983, the John Scott Award and Medal in 1989, and the Balzan Prize for the Science of New Materials in 1995.

Prof. Heeger has authored more than 600 articles in the scientific literature on the physics, chemistry, and materials science of semiconducting and metallic organic solids. He holds more than 25 patents. He serves as Editor-in-Chief of the journal *Synthetic Metals*.

"Synthetic Metals:" A Novel Role for Organic Polymers

Dr. Alan MacDiarmid, Nobel laureate, University of Pennsylvania

Abstract

The applicability of the concept of "doping" is the unifying theme that distinguishes polymers that form intrinsically conducting materials called "synthetic metals," from all other types of polymer materials. Chemical or electrochemical doping results in dramatic electronic and magnetic changes with a concomitant increase in conductivity that can enter the metallic regime. Doping phenomena and the chief types of dopable organic polymers will be discussed. A brief description will be given of very recent potential applications of conducting polymers in such diverse areas as electrostatic production of conducting nanofibers (diameter, < 100 nm) and inexpensive, disposable electronic circuits based on conducting polymers.

Biography

Alan G. MacDiarmid is the Blanchard Professor of Chemistry at the University of Pennsylvania. He received his M.Sc. degree from the University of New Zealand, and Ph.D. degrees from the University of Wisconsin and Cambridge University. MacDiarmid took part in

the historic discovery of metallic conductivity in organic polymers with Alan J. Heeger and Hideki Shirakawa. The discovery unleashed a floodgate of research world-wide in chemistry and physics concerning interrelationships between the chemistry structure and electronic properties of semiconducting and metallic organic polymers, which has continued to expand. In 2000 these three collaborators received the Nobel Prize in Chemistry for their pioneering research.

Prof. MacDiarmid is co-author of over 600 publications and approximately 30 patents, mainly on the synthesis, chemical and electrochemical doping, and characterization of the conducting polymers, polyacetylene and polyaniline and fabricated nanofibers (diameter, <100 nm) of conducting polymers and inexpensive, disposable electronic circuits based on conducting polymers.

The search for high performance polymer electronic devices

Dr. Yang Yang, University of California, Los Angeles

Abstract

Although conjugated polymer has often been considered as amorphous semiconductor, the bulk electronic and photonic characteristics are strongly influenced by the detail arrangement of polymer main chains and its side groups. Furthermore, the arrangement of polymer chains (as well as the corresponding electronic and photonic properties) can be manipulated by the processing conditions, such as the choice of organic solvents, solution concentrations, spin coating speed. In this presentation, the results from a systematic research on the control of polymer processing conditions and the improvements of polymer LEDs and photovoltaic devices will be reported.

Biography

Yang Yang earned a B.S. from National Cheng Kung University in Taiwan, and M.S. and Ph.D. degrees in physics and applied physics from the University of Massachusetts Lowell, working with Sukant Tripathy and Jayant Kumar. He is Associate Professor in the Department of Materials Science and Engineering at UCLA. Areas of research focus are: (a) Polymer and organic LEDs with emphasis on metal/polymer interface, flexible LEDs, high surface area interfaces, and high performance polymer light-emitting electrochemical cells. (b) Polymer solution LED; (b) Organic FETs. (c) Disposable bio-chemical sensors.

He was a Scientist with UNIAX Corporation, (1992-1996), where he (a) Reported the first observation of the dynamic p-n junction from polymer light-emitting electrochemical cells. (b) Solely developed conductive plastic electrodes—high surface area polyaniline electrodes—used in the polymer light-emitting diodes; reported the highest LED quantum efficiency (>2.5%) on single layer devices by applying this unique electrode. (c) Developed blue-green polymer light-emitting electrochemical devices. Achieving 4% quantum efficiency and 12 lm/w power efficiency; the highest record in its class. (d) Invented a novel polymer thin film transistor, the Polymer Grid Triode, for high speed switches. In principle, the speed of the polymer triode can be >1MHz, which is very fast for the organic devices. (e) Developed organic transistors based on sexi-thiophenes on oriented meso-epitaxy PTFE film.

His awards and honors include the NSF Career Award (1998); UCLA Young Faculty Award (1997); Who is Who in America, (1997); Who is Who in Health and Medicine (1997);

Research; Associate Fellowship from National Research Council, (1991); Professional Development Award, University of Massachusetts-Lowell, (1991); Outstanding Graduated Student Award Nomination, University of Massachusetts-Lowell, (1990, 1991). He has over 50 publications in professional and scholarly journals; 5 patents granted.

Surface Molecular Structure Determination of the Lithium Salt of 10, 12-Nonacosadiynoic Acid Monomer and Polymer Langmuir-Blodgett Films by Scanning Force Microscopy Compared to Electron Diffraction Results

Dr. Jerome Lando, Case Western Reserve University

Abstract

Langmuir-Blodgett films of lithium salts of 10, 12-nonacosadiynoic acid monomer (Li/16-8 DA) and polymer (Li/16-8 PDA) were characterized by scanning force microscopy (SFM or AFM) to study their surface molecular structure. Based on analysis of these images, a two-dimensional oblique unit mesh is assigned for Li/16-8 DA monomer LB film with unit mesh parameter $a = 0.510 \pm 0.040$ nm and $b = 0.410 \pm 0.060$ nm with an angle of 114° . A hexagonal unit mesh is assigned for Li/16-8 PDA with unit mesh parameter $a = 0.439 \pm 0.052$ nm and $b = 0.439 \pm 0.060$ nm. We then report the comparison of two-dimensional, fast Fourier transform (FFT) of SFM images to the three-dimensional electron diffraction images. From the viewpoint of a three-dimensional structure projected onto a plane, centered rectangular nets can be assigned for both Li/16-8 DA and Li/16-8 PDA. The monomer unit mesh parameter $a = 0.46 \pm 0.040$ nm and $b = 1.020 \pm 0.060$ nm. The polymer unit mesh parameter $a = 0.485 \pm 0.080$ nm and $b = 0.820 \pm 0.010$ nm. The correlation between the two very different methods, SFM and electron diffraction, of surface structure determination is excellent. However, care must be taken in assigning the unit net (two-dimensional representation) and projected unit cell vectors.

Biography

Jerome Lando earned an A.B. in chemistry at Cornell, and a Ph.D. in polymer science at the Polytechnic Institute of Brooklyn, working with Prof. H. Morawetz. He has taught at Case Institute of Technology and then Case Western Reserve since 1965, and chaired the Department of Macromolecular Science, 1978-1985. He has been Visiting Professor at the University of Mainz (Alexander Von Humboldt Senior American Scientist), at the Weizmann Institute of Science (Michael awardee), and at the Technion (Lady Davis Professor).

Lando's honors include the International Education Award, Society of Plastics Engineers (SPE), 1999; International Research Award, SPE, 1994; Distinguished Alumni Award, Polytechnic University, 1990; and the visiting professorships named above. He is a Fellow of the American Physical Society, and a current or past member of the Editorial Board of seven journals. He has authored one book, over 200 publications, and holds several patents.

Hetero-Multilayered Thin Films Made up of Polydiacetylene Microcrystals and Metal Fine Particles.

Dr. Hachiro Nakanishi, Tohoku University

Abstract

Under collaboration with the late Prof. Sukant Tripathy, we have succeeded in preparation of a multi-layered and well-oriented thin films of polydiacetylene microcrystals, and very recently further of a hetero-multilayered thin films composed of polydiacetylene microcrystals and gold or silver fine particles, all by means of electrostatic deposition technique, i.e., layer-by-layer deposition technique. The morphological structure of the hetero-layered thin films were characterized, and their linear optical properties were evaluated. Compared with spin-coated films, better optical properties, say lower loss and far higher optical densities were achieved for these hetero-layered thin films. It has been found that the absorption spectra are the simple additives of the components, indicating that no specific ground-state interactions between components are realized in these hetero-multilayers.

Biography

Professor Hachiro Nakanishi is Director of the Institute for Chemical Reaction Science, Tohoku University, Sendai, Japan. Before joining the university in 1991, he was Prime Researcher, Research Institute for Polymers and Textiles, AIST, MITI. He earned a bachelor's and master's of engineering from Tohoku University, and a Doctor of Science degree from Tokyo Institute of Technology. His research interests and activities include organic micro- and/or nano-crystals and their unique properties, organic and polymeric nonlinear optical materials, synthesis of novel polydiacetylenes, and organic and polymeric conducting crystals. His honors and awards include Project Leader, Core Research for Evolutional Science and Technology on Organic Nano-Crystals;

Project Leader, University Project on Pseudo-molecular Science; Award from the Chemical Society of Japan on Crystal Engineering of Organics and Polymers for Photonics; Award from AIST, MITI on Functional Organic and Polymeric Materials; Award from the Agency of Science and Technology on Functional Organic and Polymeric Crystals; Project Leader, MITI's National Project on Nonlinear Photonics Materials; and Senior Visiting Researcher, Cambridge University, 1978-1980. Dr. Nakanishi has published more than 300 articles.

Molecular-Level Processing of Polymers: A Means to Control the Function and Performance of Thin Film Devices.

Dr. Michael Rubner, Department of Materials Science and Engineering,
Massachusetts Institute of Technology

Abstract

In recent years, it has become apparent that electroactive organic and polymeric materials offer exciting new possibilities as the active elements of thin film optical and electronic devices. In order to exploit fully the novel behavior of these materials, it is now recognized that molecular-level processing schemes are needed to control and optimize device behavior and performance. Over the years, we have explored various molecular assembly approaches for this purpose. The most promising of these is a new layer-by-layer deposition process involving the molecular-level assembly of oppositely charged polyelectrolytes. To date, we have used this approach to control surface functionality, to improve the efficiency and light output of thin film light emitting diodes based on conjugated polymers and Ru(II) complexes, to spatially control the synthesis of metallic and semiconducting nanoparticles, and to create microporous thin films. In each case, the unique control over molecular organization and multilayer composition provided by the layer-by-layer approach was critical to the final result. Specific examples will be discussed.

Biography

Michael Rubner completed his undergraduate degree at the University of Lowell and earned his Ph.D. at the Massachusetts Institute of Technology in 1986. He was a member of the Technical Staff at GTE Laboratories, 1980-1986. He is the TDK Professor of Materials Science and Engineering at MIT, and directs MIT's National Science Foundation Materials Research Science and Engineering Center, as well as the program in Polymer Science and Engineering.

Rubner's research interests include specific 3-dimensional assemblies of macromolecules, especially the assembly of oppositely charged polyelectrolytes in layer by layer deposition.

Bright Scarlet Electroluminescence of Organic Dye

Dr. Seizo Miyata, Tokyo University of Agriculture and Technology

Abstract

Double-layer organic thin film electroluminescent devices with red color emission have been constructed using the bisanil dyes. The basic structure of the EL device consisted of a hole-transport layer and a luminescent layer between ITO glass and magnesium electrodes. The hole-transport layer was a N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'-biphenyl-4,4'-diamine

(TPD)-doped poly(N-vinylcarbazole) (PVK) film. The luminescent layer consisted of a host material, 8-hydroxyquinoline aluminum (Alq₃), and bisanil dye as the dopant. The FWHM of the PL and EL spectra of two bisanil dyes is as narrow as 50 nm. Among the two materials we discussed, the N,N'-bis[4-(N, N-dimethylamino)-benzylidene]diaminomaleonitrile (BAM) showed the best EL performance. A bright scarlet light with the peak of 620 nm and a maximum luminance of 6230 cd/m² was observed.

Biography

Seizo Miyata is Dean of the Graduate School of Bio-Applications and Systems Engineering at the Tokyo University of Agriculture and Technology, where he has taught since 1969. He has been Visiting Professor at the California Institute of Technology (1982-1983), and Visiting Scientist at AT&T, Bell Labs (1983-1984). He holds a Doctorate of Engineering, Tokyo Institute of Technology, 1969. Miyata is President of the Society of Fiber Science, Japan; past Chairman of the Organic Materials Committee, Science Council, Japan; and has served as Vice President, Polymer Society of Japan. In 1985, he received an award for the "Development of Novel Piezoelectric Polymers" from the Polymer Society, Japan.

Surface Tension-Confined Microfluidics

Dr. Kenneth Wynne, Virginia Commonwealth University

Abstract

Most microfluidic devices are constructed by photo-lithographic methods using silicon or glass substrates, by rapid prototyping of poly(dimethylsiloxane) elastomers, or by conventional machining. We have developed an alternative method for producing microfluidic devices termed Surface Tension-Confined Microfluidics (STCM). STCM exploits wetting behavior

and capillarity for guiding liquids along 2-D patterned surfaces separated by a thin spacer. With no sidewalls, fluid movement is confined to paths by surface tension.

Very intricate flow patterns, dead-ended flow paths, bubble-free filling of large chambers, and multilayer configurations can be easily obtained with no necessity for air vents (Fig. 1). Furthermore, the two-dimensional nature of such devices and the ability to use inexpensive polymeric substrates may permit economical fabrication compared with conventional microfluidic devices.

Fig.1 (A) Schematic of a STCM device, (B) photograph of an actual device with food dye-colored deionized water for visualization.

The device in Figure 1 was fabricated using polypropylene plates. A mirror image hydrophilic pattern of flow paths was generated using "reactive ink" (RI) technology. In this case, the RI consisted of a sol-gel precursor, catalyst, and propanol as a solvent. A modified Hewlett-Packard plotter with a modified pen was used for patterning. Double-sided tape provided 90 μm spacers between the two surfaces.

A model for the balance of hydrophilic / hydrophobic forces associated with STCM is derived. This model considers the tendency of a liquid (viz. water) to wet hydrophilic paths vis-à-vis the energy penalty for creation of air-liquid interfaces perpendicular to the paths due to hydrophobic 'curbs'. Predictions of critical width to height ratios agree reasonably well with experimental data.

Microfluidics applications envisaged for STCM include the production of inexpensive disposable diagnostic devices. Along these lines, we have shown that complex media such as whole blood is readily "guided" on micropaths.

Biography

Kenn Wynne earned a bachelor's degree at Providence College, a Ph.D. in Inorganic Chemistry, University of Massachusetts Amherst, and a Post Doctoral Degree, University of California, Berkeley. A professor of Chemical Engineering at Virginia Commonwealth University, he has also taught at the University of Georgia. From 1975 to 2000, he was the Program Director in Polymers at the Office of Naval Research, and ran the Research Program in Polymers at Naval Research Labs. He has served in numerous capacities for the Division of Polymer Chemistry of the American Chemical Society.

Electrospinning of Biomaterials

Dr. Gary Wnek, Virginia Commonwealth University

Abstract

Broad scientific and commercial opportunities exist for the processing of polymers using electric fields. Specific attention is given here to electrospinning, a topic that was of very recent interest to Dr. Sukant Tripathy. Of particular significance is the ability to generate polymer fibers of sub-micron dimensions using electrospinning, down to about 0.05 microns (50 nm), a size range that has been traditionally difficult to access. In our work, poly(lactic-co-glycolic acid), PLA/PGA, and poly(ethylene-co-vinylacetate), PEVA, have been deposited from solutions in methylene chloride or chloroform by electrospinning to afford morphologically tailored materials for tissue engineering and related applications. Low solution concentrations tend to

favor electrostatic spraying ('electro-aerosolization') while higher concentrations lead to spinning of fibrous mats. Preliminary observations of cell growth on PLA/PGA electrospun mats will be discussed.

Biography

A native of Amsterdam, NY, Gary Wnek received a B.S. in Chemical Engineering from Worcester Polytechnic Institute in 1977 and a Ph.D. in Polymer Science and Engineering from the University of Massachusetts, Amherst, in 1980. He was a member of the faculty of the Department of Materials Science and Engineering at MIT from 1980-87, and then joined the Department of Chemistry at Rensselaer Polytechnic Institute, where he was Department Chair from 1993-96. He also served as Director of the Polymer Science and Engineering Program at RPI. Dr. Wnek moved to VCU in August 1996 to Chair the new Chemical Engineering Program. He was a co-founder of the Dais Corporation (Now Dais Analytic Corp.) which is commercializing fuel cell materials and devices.

Dr. Wnek's research interests focus on the development of polymers with unusual electrical and optical properties, modulation of morphology in multiphase polymers using electric fields, new approaches for the fabrication of polymer scaffolds for tissue engineering, and the development of new approaches for the miniaturization of medical diagnostic systems. He has published over 100 papers, co-edited 5 books, and holds 10 U.S. patents. He has served as Associate Editor of the ACS Journal 'Chemistry of Materials' from 1989-96, and is a member of the Editorial Board of that Journal and 'Polymer-Plastics Technology and Engineering.'

Dr. Wnek was a close friend of Dr. Tripathy and will miss his enthusiasm for science, love of life, and unequivocal respect for everyone he met.

Carbazole Polymers for Photonics Applications

Dr. Hiroyuki Sasabe, Chitose Institute of Science and Technology

Abstract

Polymers and oligomers containing carbazole units in the backbone and/or in the side chain were designed and synthesized as monolithic photorefractive materials and their applications to optical image processing and associative memory were discussed. This work was a part of Nano-Photonics Materials Laboratory, Frontier Research Program, RIKEN, in the period of 1996-1999, and Prof. Sukant Tripathy was one of the final reviewers to this program.

Carbazole ring is chemically modified at the positions of 3, 6, and 9 with donor/ acceptor/ long alkyl groups easily, so we can design a monolithic unit with both photoconductive and second order nonlinear optically active responses (i.e., photorefractive responses) and develop oligomers (dimer, trimer,), dendrimers, macrocyclics, linear polymers, hyperbranched polymers etc. Systematic modification of side groups of mainchain type carbazole polymers, for example, with long alkyl chain, 9-alkyl-carbazole and/or alkyl-azobenzene reveals an effective enhancement of photorefractive properties. With a four wave mixing geometry, we could demonstrate a phase conjugated image reconstruction using these monolithic carbazole derivatives.

Biography

Hiroyuki Sasabe received B.E., M.E. and Dr. E. degrees in applied physics from the University of Tokyo, Japan. He was a research scientist at Electrotechnical Laboratory, MITI, from 1966 to 1974, an associate professor at Department of Electronics Engineering, Tokyo University of Agriculture and Technology from 1974 to 1983, and joined The Institute of Physical and Chemical Research (RIKEN) as a chief scientist (laboratory head) of Biopolymer Physics Laboratory in 1982. In 1999 he moved to Chitose Institute of Science and Technology as a full professor and chairs the Department of Photonics Materials Science. He coordinated Frontier Research Program, RIKEN, from 1986 to 1991, and manages Nano-Photonics Materials Laboratory. He also affiliated as adjunct professor of Graduate School of Saitama University during 1989-1999, University of Massachusetts Lowell, USA, during 1996-1998, and Hokkaido University during 1997-1999. Currently he affiliates as adjunct professor at Kwangju Institute of Science and Technology, Korea, since 1994, Hanyang University, Korea, since 1999, and a guest professor of Peking University, China, since 1995. His current research interests are hyper-structured molecules, organic ultrathin films, organic nonlinear optics, molecular- and bio-electronic devices. Dr. Sasabe is a member of The Engineering Academy of Japan, Physical Society of Japan, Japan Society of Applied Physics, Polymer Society of Japan, IEE Japan, IEICE Japan, Chemical Society of Japan, American Physical Society, Material Research Society (USA) and SPIE (USA).

Unimolecular Rectifiers: from Waltham to Exeter to Tuscaloosa

Dr. Robert Metzger, University of Alabama

Abstract

Sukant Tripathy, Charles Panetta and I started work on molecular rectification in 1985¹, then received funding from NTT, which ultimately supported Dan Sandman and his work with John Roy Sambles in Exeter. Sambles and Ashwell discovered that a donor(+)-pi-acceptor(-) was a Langmuir-Blodgett multilayer and monolayer rectifier, but using dissimilar metal electrodes. We confirmed this finding in Tuscaloosa by using aluminum electrodes², and most recently with gold electrodes on both sides of a monolayer of hexadecylquinolinium tricyanoquinodimethanide: the rectification ratio is as high as 27 (average =7 at 2 Volts), and the currents are as high as 100,000 electrons per molecule per second³. This all started at the University of Mississippi and GTE, when we were all very young.

- 1 R. M. Metzger, C. A. Panetta, N. E. Heimer, A. M. Bhatti, E. Torres, G. F. Blackburn, S. K. Tripathy, and L. A. Samuelson, "Toward Organic Rectifiers: Langmuir-Blodgett Films and Redox Properties of the N-4-n-Dodecyloxyphenyl and N-1-Pyrenyl Carbamates of 2-Bromo,5-(2'-hydroxyethoxy)TCNQ", J. Mol. Electronics 2(3): 119-124 (1986).
- 2 R. M. Metzger, B. Chen, U. Höpfner, M. V. Lakshmikantham, D. Vuillaume, T. Kawai, X. Wu, H. Tachibana, T. V. Hughes, H. Sakurai, J. W. Baldwin, C. Hosch, M. P. Cava, L. Brehmer, and G. J. Ashwell, "Unimolecular Electrical Rectification in Hexadecylquinolinium Tricyanoquinodimethanide", J. Am. Chem. Soc. 119(43): 10455-10466 (1997).
- 3 T. Xu, I. R. Peterson, M. V. Lakshmikantham, and R. M. Metzger, "Rectification by a Monolayer of Hexadecylquinolinium Tricyanoquinodimethanide between Gold Electrodes", Angew. Chem. Intl. Ed. Engl. on 31 Oct 2000; accepted and in press (paper dedicated to the memory of Sukant Tripathy).

Biography

Robert Melville Metzger was born in Yokohama, Japan of Hungarian parents in 1940, moved to Paris, France in 1946, to Merano, Italy in 1948, then to Los Angeles, CA in 1959. After degrees in chemistry from UCLA (1962—with W.F.Libby) and Caltech (1968 —with H.M.Mc Connell) and post-docs at Stanford (with P.G.Simpson and M.Boudart), Metzger taught Italian at Stanford

(70-71), and chemistry at the University of Mississippi (71-86) and at the University of Alabama (86-now), where he is presently Professor of Chemistry and Tricampus Director of the Materials Science Program. Metzger has published 166 papers, edited 3 books, got 1 patent, graduated 9 Ph.D.s and 1 M.S., and gave talks or spent sabbatical or other leaves in 22 countries. In 1984 he became the first Coulter Professor of Chemistry at the University of Mississippi. In 1999 he received the Blackmon-Moody Award for exceptional research at the University of Alabama.

POSTER PRESENTATIONS BY DR. TRIPATHY'S GROUP: ABSTRACTS

Thin Film Optical Sensors Employing Electrostatic Layer-by-Layer Self-Assembly

Soo-Hyoung Lee, J. Kumar, S.K. Tripathy

ABSTRACT: Thin film optical sensors for pH, metal ions (ferric and mercury) and 2,4-dinitro toluene detection were developed. To fabricate the pH sensor, a fluorescent molecule, 1-hydroxypyren-3,6,8-trisulfonate, was assembled with a polycation by electrostatic layer-by-layer self-assembly technique. The fluorescent indicator molecule exhibits distinct and well-defined emission peaks for protonated and deprotonated forms. The relative peak positions and intensity of fluorescence of the protonated and deprotonated forms change in response to pH variations. For metal ions (ferric and mercury) and 2,4-dinitro toluene sensing, the indicator molecules were covalently incorporated into poly(acrylic acid) and subsequently assembled with a polycation employing electrostatic layer-by-layer self-assembly. The sensor is based on the fluorescence quenching of indicator molecules by electron transfer from indicator to electron-deficient analytes such as ferric ions, mercury and 2,4-dinitro toluene. Fluorescence intensities decreased with increasing concentration of analytes. Quenching behavior follows Stern-Volmer bimolecular quenching kinetics. Linear increase in absorbance, film thickness and emission intensity was observed as a function of number of bilayers deposited in all these films.

Electrostatically Self-assembled Polyelectrolyte/Azo dye Film and Its Photochemical Behavior

Jin-An He, Shaoping Bian, Lian Li, Jayant Kumar,
Sukant K. Tripathy, Lynne A. Samuelson

ABSTRACT: Surface relief gratings (SRGs) were fabricated for the first time on composite films assembled by electrostatic layer-by-layer (ELBL) deposition of a polyelectrolyte, poly(dimethyl diallylammonium chloride) (PDAC), and organic azo dye, congo red (CR) and brilliant yellow (BY). The photochemical behaviors of the film before and after irradiation using 488-nm Ar⁺ laser were investigated by UV-vis absorption, reflection absorption FTIR (RA-FTIR) and FT-Raman spectroscopes. Spectroscopic results indicate that an irreversibly photoinduced degradation of CR and BY as well as its trans (cis photoisomerization simultaneously occur in the composite film. Thus, it is concluded that photochemical degradation of the azo dyes in the polymeric microenvironment in addition to gradient force induced migration from the trans (cis isomerization of the small azo dyes contribute to the SRG formation. This finding demonstrates a convenient procedure to fabricate SRGs for optical and information storage applications by using the facile ELBL technique to assemble commercially available azo dyes and polyelectrolytes.

Electrostatic layer-by-layer assembly of amphoteric TiO₂ nanoparticles for dye-sensitized solar cell

Jin-An He, Lian Li, Ravi Mosurkal, Sukant K. Tripathy,
Jayant Kumar, Lynne A. Samuelson

ABSTRACT: Using nanocrystalline TiO₂ (nc-TiO₂) as amphoteric charged particles and poly(dimethyl diallylammonium chloride) (PDAC) as a polycation or poly(sodium 4-styrene-sulfonate) (PSS) as a polyanion, nanocomposite multilayered films of the PDAC/nc-TiO₂ and nc-TiO₂/PSS were respectively prepared via the electrostatic layer-by-layer (ELBL) method. The layer-by-layer assembly of these nanoparticles proceeds linearly and the morphology of these assemblies was characterized using atomic force microscopy (AFM). The nanoscopic PDAC/nc-TiO₂ and nc-TiO₂/PSS films were sintered at 550 °C and then used as working electrodes for cis-di(thiocyanato)-N,N-bis(2,2'-bipyridyl)dicarboxylate-ruthenium(II) (N3) sensitized solar cell. The I-V characteristics of the solar cells made by the sintered polyelectrolytes/nc-TiO₂ electrodes show several interesting results. (1) The short-circuit current (*I*_{sc}) does not linearly increase with the thickness of nc-TiO₂ electrode even though the adsorption behavior of N3 dye follows the linear principle, which indicates that the efficient charge transfer inside the solar cell exists only within a limited range. (2) The precursor polyelectrolytes play a major role in the photovoltaic performance of the solar cell. The preliminary results show that the thermal stability of the polyelectrolytes may be correlated to this effect. (3) The photovoltaic performance of these solar cells, made by the ELBL method, is comparative with other traditional methods such as spin casting and offers unsurpassed control over final device thickness. Typically, a 6.2% overall efficiency was obtained under 1 sun insolation at simulated AM 1.5D using a redox I₂/I⁻ based semi solid-state [poly(ethylene oxide) (PEO)] electrolyte in the solar cell made by (PDAC/nc-TiO₂)₂₀₀ electrode.

Synthesis and Characterization of Ruthenium Dyes for Efficient Photosensitization in Nanocrystalline TiO₂ based Solar Cells

Ravi Mosurkal, Lian Li, Jin-An He, Lynne Samuelson, Jayant Kumar,
John Walker and Sukant K Tripathy

ABSTRACT: Electron transfer from colored dyes to wide bandgap semiconductors is of technological importance in photoelectrochemical energy conversion. Transition metal complexes are used as photosensitizers in photovoltaic devices based on nanocrystalline TiO₂. Presently the most efficient and stable sensitizers are carboxylated Ru(II) polypyridyl complexes. Grätzel *et al*² reported the solar to electric power conversion efficiency of 11% using a bis (4,4'-dicarboxy-2,2'-bipyridine)Ruthenium(II) complexes as charge transfer sensitizers in TiO₂. However, most of the Ruthenium dyes are limited by small absorption coefficients at wavelengths above 650 nm. To improve further the efficiency of such systems, an enhanced spectral response of the sensitizer in the red and near-IR region is required. A common way of improving the absorption spectra of a complex is to tune the π^* level by using the ligands with lowest π^* level lower than that of 4,4'-dicarboxy-2,2'-bipyridine. In this paper, the synthesis of Ruthenium dyes using 2,2'-biquinoline-4,4'-dicarboxylic acid and substituted 1,10-phenanthroline as ligands to improve the absorption in the visible and near IR region and the possibility of making a macrodye are presented. The theoretical calculations of HOMO-LUMO energies and the photo physical and photovoltaic properties of these dyes are also presented.

The analysis of the results is carried out to gain an insight into the role of energetics and electron transfer processes in these dyes, which could be very useful for developing the strategies for future design and synthesis of efficient photovoltaic dyes.

Novel Chemoenzymatic Synthesis of Azobenzene Functionalized Ribonucleic Acid

Sucharita Roy, Ramaswamy Nagarajan, Peichuan Wu, Sukant K. Tripathy, Jayant Kumar, Lynne Samuelson, Ferdinando F. Bruno

ABSTRACT: Ribonucleic acids, often called a biological jack of all trades, contribute intimately to every aspect of gene expression, including the synthesis of other polypeptide biocatalysts. The fundamental importance of recurring structural motifs and the kinetics and energetics of the complex secondary and tertiary structure of RNA has been shown to be intimately linked with its functions *in vivo*. We have developed a novel enzymatic synthetic approach for covalent attachment of photoresponsive units into the RNA backbone. The synthetic conditions of this approach are extremely mild, involving the reverse micellar solubilization of nucleic acid along with lipase in apolar hydrocarbon solvents. Lipase catalyzed acylation of the 2' hydroxyl group in the ribose sugars of the RNA molecule has been used to incorporate photo-isomerizable azobenzene groups into the RNA strands. This micellar approach was envisaged for RNA functionalization while maintaining the conformational integrity of the macromolecular backbone in neutral buffer solution. The modification of RNA using covalently attached chromophores or fluorophores can be extended to other biomacromolecular matrices leading to the development of more versatile photoactive biopolymers. The photo-isomerizable groups incorporated in the RNA molecule can serve as optical 'handles' for the manipulation of the conformation of RNA and open new opportunities for biophotonic device applications.

Polymerization of Water-Soluble Conductive Polyaniline and Polyphenol using Horseradish Peroxidase and Modified Hematin.

Ferdinando F. Bruno, Ramaswamy Nagarajan, Sucharita Roy, Jayant Kumar, Sukant Tripathy, Bon-Cheol Ku and Lynne Samuelson.

ABSTRACT: An alternative, biocatalytic approach for the synthesis of a new class of water soluble and processable polyphenols is presented. In this approach, the enzyme horseradish peroxidase (HRP) is used to polymerize phenol in the presence of an ionic template. The template serves as a surfactant that can both emulsify the phenol monomer and growing polyphenol chains and provide water solubility of the final polyphenol/template complex. This approach is a simple, one step synthesis where the reaction conditions are remarkably mild and environmentally compatible. The final product is a water soluble, high molecular weight complex of polyphenol and the template used. The approach is also very versatile as numerous templates may be used to build in specific functionalities to the final polyphenol complex. Electrical conductivities on the order of 10^{-4} S/cm and third order nonlinear optical susceptibilities $\sim 10^{-3}$ of 10^{-12} esu are also observed. Hematin (hydroxyferriprotoporphyrin) is the stable, oxidized form of the free heme center of the enzyme, horseradish peroxidase (HRP). In comparison to HRP, hematin (HEM) is an inexpensive iron-porphyrin molecule that does not contain any amino acid residues and hence has significantly higher stability in a wider range of pH conditions. We report here the development of a specifically modified hematin with tethered polyethylene glycol (PEG) chains for use as a biocatalyst in our template assisted, enzymatic synthetic approach.

This novel synthetic enzyme or syn-enzyme can serve as an effective and inexpensive alternative to HRP for the synthesis of polyaniline and polyphenol. The conductivity and spectroscopy of polyaniline and polyphenol synthesized by this PEG-hematin in the presence of the template, polystyrene sulfonate is presented.

Surface Relief Gratings on Azobenzene-Containing Polymer Films

Jayant Kumar and Sukant Tripathy, with several
members of the Center for Advanced Materials

ABSTRACT: An overview is presented of the processes involved in inscribing surface-relief gratings (SRGs) on azobenzene-containing polymer films, which were first reported in 1995 by our Center and independently by a Canadian research group. Since then SRGs have been produced by several groups on amorphous side-chain and main chain azopolymers, and on liquid-crystalline azopolymers, mostly in the form of spin-coated films, but also on sol/gel, Langmuir-Blodgett (LB) and layer-by-layer films. SRGs are inscribed by impinging an interference pattern of laser light onto the film, which causes mass transport over micrometer distances at temperatures well below the glass transition of the polymer. Because the transport is associated with the molecular reorientation upon isomerization, the presence of an azochromophore is essential. When modest light intensities are used, mass transport is predominantly light driven, with negligible thermal effects. SRGs thus fabricated depend on the polarization of the writing beams, and can be erased either optically or thermally. They are π -shifted in relation to the interference pattern, which means that the molecules are moved away from the illuminated regions, and have considerable depth only where there is variation of both light intensity and field gradient. These features can be explained by a model developed in our Center, which is based on a field gradient force. Applications of SRGs on azopolymers include diffraction gratings for holography, waveguiding, alignment of liquid crystals and fabrication of intricate patterns. Our current research involves the use of high molecular weight azobenzene-functionalized cellulose, investigation of the effects from electrostatic interactions in layer-by-layer films, whose SRGs depend on photodegradation processes, and Raman microspectroscopy that allows the state of chromophores to be probed in different regions of an SRG.

The Higher Order Nonlinear Optical Properties of a Poly(DCHD) Nanocrystal Film Assembled by Electrostatic Adsorption

Ke Yang, Jin-An He, Jayant Kumar, and Sukant K. Tripathy, Lynne A. Samuelson, Toshiyuki Oshikiri, Hideyuki Katagi, Hitoshi Kasai, Shuji Okada
Hidetoshi Oikawa, and Hachiro Nakanishi

ABSTRACT: Electroabsorption spectroscopy is used to investigate the fifth order nonlinear optical properties of a poly(DCHD) nanocrystal film assembled by electrostatic adsorption. The behavior of the fifth order spectrum is in excellent agreement with the theory obtained from time independent perturbation approach. The fifth order spectrum also clearly identifies the vibrational states, which are not well resolved in the linear absorption spectrum. These vibrational energies are consistent with those obtained from poly(DCHD) bulk crystal at low temperatures.

Biological Route to Novel Electronic and Photonic Materials

Wei Liu, Ramaswamy Nagarajan, Peichuan Wu, Sucharita Roy, Jayant Kumar, Sukant Tripathy, Ferdinando F. Bruno and Lynne Samuelson

ABSTRACT: Our approach to the design and synthesis of electroactive and photonic polymers has been to use biocatalytic one pot synthesis, eliminating the need for post processing. In this approach, peroxidases (horseradish peroxidase and biomimetic catalysts) were used in the polymerization of aniline and functional phenols, water-soluble conducting polyaniline complexes, photoactive polyazophenol, and strongly fluorescent polystilbenes among others were synthesized. Unusual electronic and optical properties of these systems have been investigated. Fabrication, of photonic structures employing light driven transport will be discussed.

Novel Photodynamic Azobenzene-modified Polymers: Azocellulose

Suizhou Yang, Ashok L. Cholli, Lian Li, Monsy M. Jacob, Jayant Kumar, and Sukant K. Tripathy

ABSTRACT: Azobenzene-modified cellulose (azocellulose) polymers have been successfully synthesized through covalently linking 4-cyanophenylazophenol to natural cellulose by Mitsunobu ether formation reaction. These novel polymers with degree of substitution (DS) ranged from 0.13 to 0.99, obtained by varying the molar ratios of reactants, were characterized by solid-state ^{13}C NMR, FTIR and UV-visible spectroscopies. The experimental results show that coupling reaction preferentially occurs at the C6 carbon site and the primary alcohol is the most reactive group among the three kinds of hydroxyl groups along the main chain of cellulose. The thermal stability of azocellulose polymers was also investigated by TGA. Photoinduced birefringence exhibited a linear increase with the content of azo chromophore in the polymers. Birefringence as large as 0.11 has been achieved for an azocellulose polymer with a DS of 0.99. Surface relief gratings have also been photoinscribed on the films of the polymers. High diffraction efficiency about 25% with a surface modulation over 300 nm was obtained for high degree functionalized azocellulose polymer films.

Rubber Modified Water-Soluble Polyaniline Latex

Changshu Kuo, Long Y. Chiang, Jayant Kumar, Lynne Samuelson, and Sukant K. Tripathy

ABSTRACT: Core-shell composite of rubber latex covalently bonded with water-soluble polyaniline (PANi) has been demonstrated. 4-styrenesulfonic acid, sodium salt was polymerized by a radical initiator in the presence of polybutadiene (PBD) which was first dispersed in an ethylene glycol solution. The synthesis of a polymeric complex of PANi was next carried out by using ammonium persulfate as the oxidant in hydrochloric acid aqueous solution containing this rubber/poly(4-styrenesulfonic acid, sodium salt) core-shell like copolymer. Uniform and stable water-based PANi/PBD core-shell latex was achieved even with the PANi content as high as 58 wt%. Covalent bonding and core-shell structure in this rubber/PANi latex have provided a number of modification possibilities including the use of these water based composites as corrosion protection coatings.

Manipulating DNA Conformation Using Intertwined Electronic and Photonic Polymers

Ramaswamy Nagarajan, Sucharita Roy, Wei Liu, Jayant Kumar, Sukant K. Tripathy, Ferdinando F. Bruno and Lynne A. Samuelson*

ABSTRACT: In the field of inherently conducting polymers, polyaniline has elicited tremendous interest due to its promising electrical properties and unique redox tunability. Synthetic routes involving the use of polyelectrolytes have significantly improved the processability of polyaniline. Recently, a template guided synthesis catalyzed by an enzyme, horseradish peroxidase (HRP), has provided a means of polymerizing aniline under milder pH conditions (pH 4.3) and subsequently widened the choice of templates to more delicate biological macromolecules. Here we report a strategy that exploits the inherent molecular order as well as the polyelectrolyte behavior of DNA to enzymatically synthesize and biologically assemble conducting polyaniline. The use of a biomimetic enzyme PEG-hematin for the synthesis of polyaniline in the presence of DNA has also been explored. The “wrapping” of polyaniline on DNA has been found to induce reversible changes in the secondary structure of DNA leading to the formation of an over-wound polymorph. The polyaniline synthesized on the DNA also exhibited a template-induced macro-asymmetry. This unique polyaniline/DNA intertwined complex has been used to “probe” and control the conformation of the DNA double helix. This approach is generic and synthetic oligonucleotides have also been used as templates for the synthesis of polyaniline. Recent studies have also included complexation of optically responsive materials like azobenzene to the DNA for potential photo-induced conformational control of the DNA and this will also be presented.

Nanocomposite Films Derived from Functional Aluminosilicate through Electrostatic Layer-by-Layer Assembly

Dong Wook Kim, Alexandre Blumstein, Jayant Kumar, Changmo Sung and Sukant K. Tripathy

ABSTRACT: Multilayered nanocomposite films were prepared from aluminosilicate platelets with functional chromophores and polyelectrolytes through electrostatic layer-by-layer assembly. Fluorescent dye coumarin was intercalated into the layered aluminosilicate hectorite and the resulting hectorite/coumarin intercalation complex particles were broken down to individual platelets by means of extensive shaking and sonication of their water suspension. Atomic force microscopy and transmission electron microscopy data show that the exfoliated platelets have the form of lathes approximately 10-40 nm wide, 150-400 nm long and of an average thickness of 2-3 nm. This last value is consistent with the overall thickness of a single aluminosilicate lamella sheathed with coumarin molecules on both sides. Given the strong negative surface charge of the aluminosilicate layers, films of nanocomposites could be formed by electrostatic layer-by-layer assembly using a cationic polyelectrolyte. The AFM topography of such films revealed a homogeneous monolayer coverage of the underlying substrate. Linear build-up of the multilayer films up to 20 cycles was demonstrated and investigated using UV/vis absorption spectroscopy. The resulting transparent films have exhibited strong characteristic blue-green fluorescence due to coumarin dye molecules adhered to the exfoliated hectorite platelets.

Preparation of Organic/Inorganic Nanocomposites by Intercalative Spontaneous Polymerization of 2-Ethynylpyridine within Montmorillonite

Dong Wook Kim, Huaibing Liu, Mike Downey, Jayant Kumar,
Sukant K. Tripathy, and Alexandre Blumstein

ABSTRACT: Intercalation complex of a conjugated substituted polyacetylene and montmorillonite were prepared through intercalative spontaneous polymerization of the acetylenic monomer. Spontaneous polymerization and formation of extensive conjugation were evidenced by the investigation with FT-IR and UV/vis absorption spectroscopy. Brønsted acidic species residing within the galleries of montmorillonite may be responsible for activating the monomer to be polymerized. X-ray data supported the model of one layer of the polyacetylene inserted between the lamellae of the aluminosilicate with pyridine rings of the repeating unit oriented nearly perpendicularly to the surface of the lamellae.

Polycation Effects on Electronic Spectra of Conjugated Polymers in Programmed Electrostatic Assemblies

Myunghwan Kim and D.J. Sandman

ABSTRACT: Conjugated polymers, namely a polydiacetylene and a poly-3-alkylthiophene, as carboxylates undergo programmed electrostatic assembly with ammonium, pyridinium, and chitosan polycations. These assemblies were studied by electronic spectroscopies with attention paid to local environmental effects and also to the effects of post assembly processing with acids and bases.

Structural Aspects of the Thermochromic Transition in the Polydiacetylene Bis(ethylurethane) of 5,7-Dodecadiyne-1,12-diol(ETCD)

Dong-Chan Lee, D.J. Sandman, Sangrama K. Sahoo, Monsy M. Jacob, and A.L. Cholli

ABSTRACT: The polydiacetylene ETCD undergoes a first order thermochromic phase transition near 125 deg. C. In this work, the transition is studied by solid state NMR and thermal methods. Also studied is the nonthermochromic form of poly-ETCD.

Use of Carbohydrate Reagents for the Polymerization of Dicyanoalkenes and—Arenes

Ik-Bum Kim and D.J. Sandman

ABSTRACT: In this communication, we describe the polymerization of several dicyanoalkenes and arenes to high molecular weight conjugated polymers using, for the first time, initiation by unmodified carbohydrate reagents under mild conditions. The polymers that we prepare as described herein have either not been previously prepared or have improved properties compared to closely related polymers prepared by other routes. Evidence for the structure and properties of these polymers will be presented.

IN MEMORIAM: SUKANT TRIPATHY

Sukant K. Tripathy, professor of chemistry at the University of Massachusetts Lowell, died Tuesday, Dec. 12, in a swimming accident in North Kohala, Hawaii, while attending the American Chemical Society international conference.

Born in Bihar, India, he was a graduate of the Indian Institute of Technology and received his Ph.D. from Case Western Reserve in 1981. Dr. Tripathy worked at GTE as manager of the organic and polymer materials sciences department from 1981 to 1986. He joined the faculty of UMass Lowell in 1985 as a professor of chemistry. He founded and had served as director for the Center for Advanced Materials since 1992. He also served as provost and vice chancellor for academic affairs from 1994 to 1996.

Members of the campus community joined Tripathy family and friends on Dec. 21 for a memorial service to mourn the loss of a leading researcher, inspirational teacher, mentor to students and colleagues alike, and an exceptional individual.

Speakers at the service had deeply personal memories, recalling Dr. Tripathy's intense gaze, his incisive intellect and encyclopedic knowledge of matters from optical polymers to baseball statistics, his legendary energy and kind attention to all, and his boundless optimism and enthusiastic encouragement of others to achieve greatly.

The University is holding this second memorial service for Dr. Tripathy to accommodate his many international colleagues and friends. Papers from the technical symposium in his honor will be published in a special issue of the *Journal of Macromolecular Science*, dedicated to Sukant Tripathy.

Dr. Tripathy was recognized as a world leader in research in the broad area of polymers in electronics and optics; he was awarded the 1993 Carl S. Marvel Creative Polymer Chemistry Award of the ACS Division of Polymer Chemistry. He published more than 200 refereed research articles and held two dozen patents.

At UMass Lowell, Dr. Tripathy had taught chemistry since 1985. He founded and had served as director of the Center for Advanced Materials since 1992. He also served as provost and vice chancellor for academic affairs from 1994 to 1996. Before joining the faculty, he was manager of the organic and polymer materials sciences department at GTE. Born in Bihar, India, he was a graduate of the Indian Institute of Technology and received his doctorate from Case Western Reserve in 1981.

Dr. Tripathy is survived by his wife Susan Thomson and children Sheila, 13, and Aneil, 10, of Acton; and by his parents, two brothers, and a sister, who live in India.

SUKANT K. TRIPATHY MEMORIAL FUND

The University has established the Sukant K. Tripathy Memorial Fund to support research. Those wishing to make a donation should make it payable to Sukant K. Tripathy Memorial Fund, and mail it to University of Massachusetts Lowell, Office of University Advancement, 600 Suffolk St., Lowell, MA 01854-3629.

